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(71)Applicant : HITACHI LTD

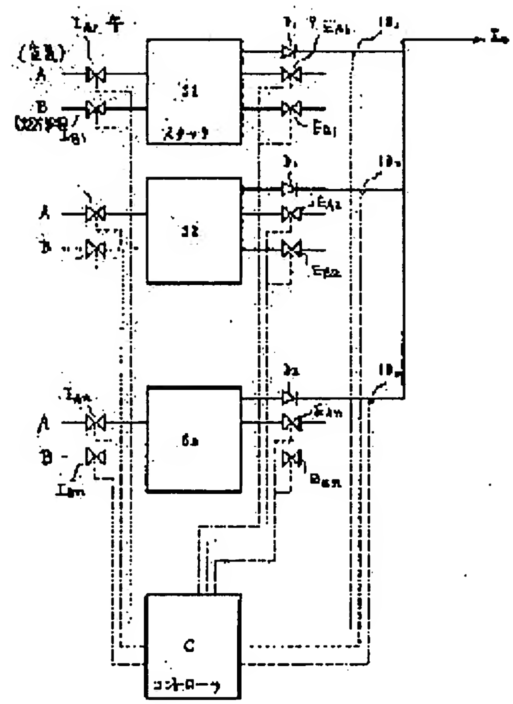
(72)Inventor : SATO TAKAO
HORIUCHI SUSUMU

(54) CONTROL DEVICE FOR FUEL CELL

(57)Abstract:

PURPOSE: To properly and automatically control each current of a plurality of fuel cell stacks which are connected in parallel while even variation with time is being taken into consideration, and thereby enhance reliability.

CONSTITUTION: A controller C compares the detected output current of fuel cell stacks S1 through Sn connected in parallel, with target values separately set by each so as to control gas feed valves IA and IB for the respective stacks, so that each gas pressure within the respective fuel cells is thereby optimized. The controller also controls the concentration, temperature and the like of oxidizing gas A and fuel gas B. Moreover, as the aforesaid target value, the two kinds of values are set, the aforesaid control is usually executed based on the first target value, and when fuel cell performance is deteriorated, execution is shifted to control based on the second target value.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the fuel cell which supplies and generates the fuel of a hydrocarbon system at the control unit of **** and the fuel cell which carries out parallel connection especially of the fuel cell cel stack, and supplies power to a load.
[0002]
[Description of the Prior Art] A fuel cell generates direct current power by the electrochemical reaction of a fuel and an oxidizer. It is the point that that effectiveness is high differs from other generation-of-electrical-energy facilities greatly with a quiescence mold. Generally, parallel connection of the cel stack of a fuel cell is carried out, it is large-capacity-ized, a direct current is changed into an alternating current with an inverter, and a load is supplied.
[0003] Drawing 14 is the block diagram of conventional phosphoric acid mold fuel cell equipment. The fuel cell stack 1 of a phosphoric acid mold is generated in response to supply of a fuel (hydrogen) and air (oxidizer). H2 [moreover,] obtained by the reforming machine 2 carrying out the pyrogenetic reaction of the steam to material gas (natural gas etc.) -- supplying rich fuel gas to the fuel cell stack 1 as a fuel, a mixer 3 mixes a steam with the above-mentioned material gas, and the pressurization machine 7 pressurizes the above-mentioned air. The fuel exhaust gas containing the hydrogen which the fuel cell stack 1 exhausts is sent to the reforming machine 2, burns, and heats the reforming machine 2 to predetermined temperature.
[0004] Moreover, a pump 8 supplies cooling water to the fuel cell stack 1, and cools generation of heat accompanying a generation of electrical energy. This cooling water evaporates on the steam drum 4, and is supplied to a mixer 3. The heater 6 for starting is formed in the steam drum 4, and cooling water is warmed at the time of starting. Moreover, a heater 6 is used also as a dummy load in adjustment at the time of the below-mentioned starting. The dc output of the fuel cell stack 1 is changed into an alternating current by the inverter 5. A control system 9 controls the magnitude of the above-mentioned ac output, effective power, etc. C is a control unit which controls the whole fuel cell equipment.
[0005] Drawing 15 is the perspective view showing an example of the internal structure of a phosphoric acid mold fuel cell. Sandwich structure of the air pole which added the fuel electrode which added the catalyst (platinum), the electrolyte (phosphoric acid), and the catalyst (platinum) is made into one unit (cel), since the cel electrical potential difference is low, the laminating of this is carried out and it is stack-ized. However, since carbon is a charge of a principal member like illustration, and a limitation is in a mechanical strength, and the number of laminatings is enlarged and is not made with it being thoughtless, series parallel connection of two or more stacks was carried out, and they have been large-capacity-ized.
[0006] Moreover, the above-mentioned stack is sealed in an inner lift, and an inner lift is held in the outside tub which closed inert gas, such as nitrogen (N2), and he is trying for the atmospheric-pressure difference between an inner lift and an outside tub not to exceed the predetermined range further. In this case, there are two methods of the ordinary pressure type which makes the pressure of an inside-and-outside tub almost equal to atmospheric pressure, and the pressure type carried out more than atmospheric pressure. Moreover, a fuel is supplied from the end of the fuel electrode of a cel, 80% of the abbreviation for hydrogen is ionized and consumed, and it is exhausted from the other end. Air is similarly supplied from the end of an air pole, and after oxidizing the above-mentioned hydrogen ion by the oxygen in it and generating water, it is exhausted from the other end. A stack is equipped with the above-mentioned fuel and four ducts supply of air, and for exhaust air, and a fuel and air are distributed to each cel in a stack.
[0007] Drawing 16 is the output voltage and the current characteristic of the above-mentioned fuel cell stack, and is accompanied by variation like illustration by manufacture variation etc. Drawing 17 is the aging property of output voltage. Even if the aging property has the same fuel amount of supply, it changes with stacks, and by

****.of the electrolyte in early stages of operation etc., to the same gas stream and the same current, an electrical potential difference increases temporarily or carries out monotone reduction of it. Moreover, since disperse, and electrolytes decrease in number or a catalyst condenses in proportion to accumulation operation time after that, output voltage decreases uniformly.

[0008] Thus, since some variations are in output voltage, in carrying out parallel connection of the cell, as shown in drawing 18 , it connects each fuel cell stack S1 and S2 grade through the diode D1 for antisuckbacks, and D2 grade. However, as everyone knows, since the output voltage of parallel connection is fixed to the electrical potential difference of a fuel cell stack with the largest electrical potential difference, the current of a cell with low output voltage becomes low relatively, the output current will be supplied from a cell with mainly high output voltage, and it increases in connection with this, the gas input rating of gas utilization, i.e., the rate, of the cell concerned, and if the rate of gas utilization exceeds a limit, electrode corrosion will occur.

[0009] Since output voltage hardly changes in the predetermined range of the rate of gas utilization as shown in drawing 19 , the above-mentioned problem tends to generate especially a fuel cell. Moreover, in the system equipped with the reforming machine for every fuel cell stack, as a result of the fall of the rate of a cell with the above-mentioned low electrical potential difference of gas utilization, since the fuel concentration of the fuel exhaust gas which returns to a reforming machine becomes high and reforming machine temperature rises, the cell control approach is complicated. Setting the fuel for each cell and the flow rate of air to Japanese Patent Application No. No. 144989 [58 to] according to a predetermined output current ratio is indicated.

[0010]

[Problem(s) to be Solved by the Invention] However, by the approach of an above-mentioned Japanese Patent Application No. [No. 144989 / 58 to] indication, since each output current ratio was decided and flow rates, such as each fuel and air, were set up according to this from the output characteristics of each fuel cell measured beforehand, there was a problem that it could not respond, for example to aging, a temperature change, and change with other difficult prediction. The purpose of this invention is to offer the fuel cell which can solve the above-mentioned problem, can adhere to property fluctuation of aging, a temperature change, and others, and can equalize output power, this current density, etc. of each fuel cell that there is nothing.

[0011]

[Means for Solving the Problem] In order to attain the above-mentioned technical problem, the fuel gas of the fuel gas of each fuel cell stack, the pressure of air, and/or each fuel cell stack, the gas concentration of air, and/or the temperature control means of each fuel cell stack are controlled for the output current and its output current command value of each fuel cell stack. For this reason, control the above-mentioned pressure by the valve prepared in the fuel gas of each fuel cell stack, the feed hopper of air, and the exhaust port, the temperature of the cooling water of each fuel cell stack is controlled, or the concentration of the above-mentioned fuel gas and air is controlled by above-mentioned Blois.

[0012] Moreover, it controls by the oxygen concentration means which connected the above-mentioned gas concentration to the air supply valve of each fuel cell stack, the above-mentioned air supply valve, and juxtaposition. Moreover, the comprehensive output current actual as the 2nd desired value was multiplied by the rated capacity ratio of the fuel cell stack [as opposed to the rated capacity of the whole fuel cell stack for what multiplied synthetic output current desired value by the rated capacity ratio of the fuel cell stack concerned to the rated capacity of the whole fuel cell stack as the 1st desired value of the above-mentioned output current] concerned again, and a thing setup is carried out.

[0013] Moreover, the supply valve of the fuel gas of the fuel cell stack concerned and air is controlled by the 1st desired value of the above, and the exhaust port valve of the fuel gas of the fuel cell stack concerned and air is controlled by the 2nd desired value. Moreover, on the basis of the opening of the valve set up according to the above-mentioned output current desired value, one of the valves of the gas passageway of another side is set up so that the differential pressure between gas passagewaies may be settled in this allowed value, and two valves which remain further are controlled from the flow rate set point of each gas, and the fluid resistance value of each above-mentioned gas passageway, or it sets up so that it may be settled in the differential pressure allowed value between each gas passageway. Furthermore, an alarm is generated when the output current value of synthesis of a fuel cell stack becomes below a predetermined value.

[0014]

[Function] The output current of each fuel cell stack is controlled by the fuel gas of the pressure of the above-mentioned fuel gas and air, and/or each fuel cell stack, the gas concentration of air, and/or temperature of each fuel cell stack. The above-mentioned pressure is controlled by the fuel gas of each fuel cell stack, the supply valve of air, and the exhaust valve. Moreover, the above-mentioned gas concentration is controlled by the air supply valve of each fuel cell stack, and the oxygen concentration means which carried out parallel connection to this.

[0015] Moreover, each fuel cell stack is usually controlled by the 1st desired value of the above, and when current-output capacity declines, it is controlled by the 2nd desired value. Moreover, the supply valve of the fuel gas of the fuel cell stack concerned and air is controlled by the 1st desired value of the above, and this exhaust valve is controlled by the 2nd desired value. Moreover, one of the valves of the gas passageway of another side is set up in the differential pressure allowed value between gas passagewaies on the basis of the opening of one valve set up according to the above-mentioned output current desired value, and the controlled variable of two valves which remain is calculated from the flow rate set point of each gas, and the fluid resistance value of each above-mentioned gas passageway, and it is set up in the differential pressure allowed value between each gas passageway.
[0016]
[Example] In this invention, the rate of a current assignment of each fuel cell stack which controls and carries out parallel connection of the affecting parameter to the output voltage of the fuel cell of a phosphoric acid mold is controlled and equalized to a predetermined value.
[0017] [Example 1] Drawing 1 is the block diagram showing the principal part of the fuel cell equipment example by this invention which controls pressures supplied to a fuel cell stack, such as hydrogen and air. Air (oxidizer) is supplied to n fuel cell stacks S1-Sn through Valves IA1-IAn, respectively from the oxidizer supply edge A, and it exhausts through Valves EA1-EAn. Fuel gas (H2 is contained) is similarly supplied through Valves IB1-IBn, respectively from the fuel-supply edge B, and it exhausts through Valves EB1-EBn. Moreover, the exhaust gas from Valves EA1-EAn turns to a heat energy recovery system, the exhaust gas from Valves EB1-EBn is sent to a reforming machine, and the residual fuel component in it is used.
[0018] The hydrogen supplied in a cel ionizes the fuel cell of a phosphoric acid mold, and since it generates electricity, and it combines with oxygen and the ionized hydrogen ion changes to water, output voltage increases in proportion to the fuel (hydrogen) pressure in the inner layer which holds a cel, as shown in drawing 2 , and increases also with the air (oxygen) pressure in a inner layer like drawing 3 . Moreover, the output current is proportional to this output voltage. However, since a gas cross will occur among two poles if the differential pressure between the above-mentioned fuel electrode and an air pole becomes excessive, as this differential pressure did not exceed a predetermined limit, it has prevented direct oxidation reaction of non-ionized gas.
[0019] Moreover, as the differential pressure between the inner lift of a stack and an outside tub did not exceed the predetermined range, either, it has prevented breakage of the seal section between inside-and-outside tubs. In a fuel cell, as each above-mentioned flow and pressure requirement is fulfilled, it is started, and operation is continued. Drawing 4 is the operating procedure Fig. of the fuel cell the time of the above-mentioned starting, and after starting.
[0020] (Control at the time of starting) The operating procedure at the time of starting is explained using the flow chart first shown in drawing 5 about the ordinary pressure type which maintains the pressure of an outside tub at atmospheric pressure. First, after closing all valves and carrying out the temperature up of a reforming machine, each stack, the cooling water system, etc. to predetermined temperature, the reforming machine 2 is started, and subsequently a fuel and air are supplied a minute amount every by actuation of a valve. Since output voltage begins to rise by this, the opening of a fuel valve and an air valve is increased gradually, and output voltage is made to increase to a predetermined value.
[0021] Subsequently, parallel connection of each stack is carried out, and a dummy load is connected. At this time, if output voltage is beyond a predetermined value, in memorizing the opening of the fuel valve and air valve at that time and being less than the above-mentioned predetermined value, the stack concerned judges with it being unusual, and emits an alarm. In addition, in the pressure type which keeps an outside tub higher than atmospheric pressure, after passing inert gas on an outside tub, a fuel, and an airstream way and pressurizing an inside-and-outside tub mostly at this ** at coincidence, it starts with the same procedure as the above. In addition, in each above-mentioned process, the pressure regulating valve which supplies the above-mentioned inert gas to the outside tub which abbreviated illustration to each differential pressure not exceeding a predetermined value with the opening of a fuel valve and an air valve is adjusted, carrying out the monitor of the differential pressure between the fuel supplied to each stack, the differential pressure between air, an inner lift, and an outside tub.
[0022] (Control after starting) The output current of each stack changes with the causes of aging, or temperature fluctuation and others after starting. For this reason, the current detectors ID1-IDn are connected for every output of each stack like drawing 1 , the output current is supervised, the opening signal of each valve is computed from each output current value by Controller C, and each valve is controlled by this invention.
[0023] Drawing 6 is the equal circuit of the fuel system of a stack, and an air processing subsystem. each parameter in an air processing subsystem and a fuel system -- Suffix A -- said -- it has distinguished by B. That

is, fluid resistance of the input control pressure of an air processing subsystem and the input valve IA, Stack S, the output valve EA, and an exhaust air system is set to P1A, and RIA, RSA, REA and ROA, respectively, and fluid resistance of the input control pressure of a fuel system and an input valve, a stack, an output valve, and an exhaust air system is set to P1B, and RIB, RSB, REB and ROB, respectively. If they are usually disregarded since ROA and ROB are low values compared with other resistance, and leakage resistance RL is also disregarded, each above-mentioned pressure value will become as shown in a formula (2) and (3).
[0024]
P2A=P1A(RSA+REA)/(RIA+RSA+REA)
P2B=P1B(RSB+REB)/(RIB+RSB+REB) (2)
P3A=P1AREA/(RIA+RSA+REA)
P3B=P1BREB/(RIB+RSB+REB) (3)
[0025] As shown in drawing 2 and 3, the output voltage of each stack is controllable by the pressure of a fuel or/and air. Fuel pressure is the average of the above-mentioned P2A and P3A, and air pressure is the average of the above-mentioned P2B and P3B. Therefore, from the output current detection value of each stack, Controller C computes the opening of four valves for every stack, and controls each fluid resistance value RIA, REA, and RIB and REB.
[0026] However, generally the controlled variable (dependent variable) of 4n valve cannot be determined from the output current (independent variable) of n stacks S1-Sn. For this reason, in this invention, the dependency between RIA, REA and RIB, and REB, the dependency between RIA, RIB and REA, and REB, etc. are defined beforehand. For example, the monitor also of the differential pressure between the inner lift of a stack and an outside tub is carried out, it sets up the allowed value of this differential pressure, and fixes either the above-mentioned P2A or P2B to the internal pressure of an outside tub.
[0027] Subsequently, since pressure P3A and P3B by the side of appearance become as shown in a formula (4) and (5), if flow rates QA and QB are set up according to the stack current value at the time, the value of P3A and P3B will be automatically set up from the value of P2A and P2B.
P3A=P2A-RSAQA (4)
P3B=P2B-RSBQB (5)
Moreover, if the monitor of the differential pressure deltaP2 between P2Bs is carried out to P2A with a differential pressure gage and it is made for these deltaP2 not to exceed a predetermined value, another side can be automatically set [one side / of P2A and P2B] up from a formula (6).
P2B=P2 A**delta P2 (6)
[0028] If one of for example, the input valves is controlled by the output current of a stack, the input valve of another side is automatically controlled by the above from a formula (6), and, subsequently two output valves can also be automatically controlled by it according to a formula (4) and (5). Moreover, the valve controlled by the above-mentioned output current does not necessarily need to be one of the input valves, may be any of four I/O valves and can determine other three controlled variables automatically by one control from formula (4) - (6). In the case of said pressure type, the output current is detected, and it controls an inner lift pressure, and according to this inner lift pressure, it controls an outside tub pressure so that the differential pressure between inside-and-outside tubs does not exceed a predetermined value. Moreover, an outside tub pressure is controlled based on the output current, and you may make it control an inner lift pressure according to this.
[0029] Drawing 7 is the flow chart which generalized the above-mentioned relation. First, if one in four above-mentioned pressure P2A and P2Bs, P3A, and P3B, P1 [for example,], is determined from the allowed value of an inner lift and the differential pressure between outside tubs and the pressure P2 of other passage is subsequently determined from the differential pressure allowed value between fuel passage and an airstream way The pressures P3 and P4 of the other end of each passage are determined by the flow rate values Q1 and Q2 doubled with the stack current value at the time. After that, the balance control of each output current is added and the above-mentioned control is performed repeatedly. For this reason, the controller C shown in drawing 1 memorizes the above-mentioned inner lift, the differential pressure allowed value between outside tubs, the differential pressure allowed value between fuel passage and an airstream way, each flow rate value, etc., and generates the control signal of each valve with the above-mentioned procedure according to the output current of each stack.
[0030] In addition, same control can be performed even if it detects the air of each stack, and the pressure of a fuel I/O edge. Moreover, since the differential pressure between air and a fuel will become low if the above-mentioned P2A, P3A, P2B, P3B, etc. settle down in predetermined width of face by the above-mentioned control, respectively, leakage resistance RL can be disregarded compared with other resistance.
[0031] [Example 2] This example is concerned with countermeasures when the output current is unmaintainable to desired value with degradation of a stack. First, since the rated capacity of each stack generally is not

necessarily equal, the ratio of the rated capacity of the stack concerned to the whole rated capacity is taken into consideration, and the 1st desired value of the output current is set up. Namely, the output current desired value IOi of a No. i stack is defined like a formula (7) by setting the 1st desired value of the above to IO.
IOi=IOx(rated capacity of i-th stack)/(the whole rated capacity)
(7)
[0032] In fact, since the situation where it becomes impossible to pass the above-mentioned output current desired value generates each stack by degradation with time etc., it will be necessary to continue operation, correcting Above IO. It controls to make the current of each stack in agreement with Above IOi at a stage with little degradation, and when it becomes impossible to pass this IOi, according to the 2nd desired value set up separately, it controls by this invention from actual total output current.
[0033] The 2nd desired value of the above-mentioned No. i stack sets actual total output current to IOO, and defines it like Iim of a formula (8). Since this Iim multiplies Above IOO by the rated capacity ratio, it will call it the output average of a No. i stack.
Iim=IOOx(rated capacity of i-th stack)/(the whole rated capacity)
(8)
[0034] Drawing 8 is the block diagram of the above-mentioned control. The differential signal of the output of the function generator FG1 according to the output set point of a No. i stack and the output current Ii of the No. i stack through a function generator FG3 is impressed to Valves IAi and IBi through PID1 (the proportionality for abolishing the conventional steady-state deviation, an integral, derivation machine), and the opening is controlled. In changing the response of the input valves IAi and IBi to the above-mentioned control signal, after branching the output of PID1 suitably and multiplying by the predetermined multiplier (function), it impresses by Valves IAi and IBi, respectively.
[0035] Moreover, although omitted, since the differential pressure between an inner lift and an outside tub changes according to the opening of the above-mentioned valves IAi and IBi, it controls by drawing 8 so that this differential pressure is settled in a predetermined value like an example 1. Moreover, the output valves EAi and EBi of air and a fuel are similarly controlled by the average output current Iim. When a No. i stack can output the above-mentioned desired value IOi, the value of IOi and the average output current Iim is in agreement. When degradation of a stack with time becomes excessive, Above Iim stops however, catching up with IOi.
[0036] Since it works according to this fall of Iim so that control may increase an inner lift pressure, the opening of the output valves EAi and EBi decreases. Consequently, since flow rates begin to run short, it will be necessary to open an input valve. For this reason, Controller C increases the opening of an input valve gradually and it is made for the flow rate values Q1 and Q2 of air and fuel gas to turn into a initial value. At this time, each valve is readjusted according to formula (4) - (6). For this reason, the conversion table of Above Iim and the opening of an input valve is stored in Controller C, and the above-mentioned correction can be made. Moreover, an alarm is emitted when the above Q1 and Q2 exceeds a predetermined limit.
[0037] Hand regulation can also amend the above-mentioned degradation with time. That is, when Above Iim stops catching up with IOi, Controller C generates a readjustment status signal, and according to this, an operator adjusts the valve of each stack and reduces desired value IOi suitably.
[0038] Drawing 9 is the block diagram of this invention example which forms Limiter LMI before the input valves IAi and IBi in above-mentioned drawing 8 , and restricted each control value. Since the breakthrough of the gas between **** will occur if the differential pressure between an air pole and a fuel electrode becomes excessive, the limiting value of the above-mentioned limiter LMI is set up with air and the differential pressure value dp between fuel feed hoppers, and it is made for the differential pressure between the air pole of Stack i and a fuel electrode not to exceed a predetermined value.
[0039] [Example 3] Since the output voltage of a phosphoric acid mold fuel cell changes according to the concentration of hydrogen or oxygen as shown in drawing 2 and 3, it can control the hydrogen concentration in fuel gas, and the oxygen density in air, and can control the output current of each stack. Drawing 10 is the block diagram of this invention example which performs the above-mentioned concentration control. Since some of air supplied to Stack Si and fuels are exhausted as surplus gas, it returns each to an input side by Blois BL1 and BL2 for circulation, controls the concentration of the gas in Stack Si, and controls the output current.
[0040] the engine speed of Blois BL1 and BL2 -- each -- since a mixing ratio changes, the output current of Stack Si is controllable by the engine speed of Blois BL1 and BL2. For example, the rotational frequency of Blois BL1 and BL2 is controlled by the error signal acquired as compared with desired value IOi, Iim, etc. which explained the output current of Stack Si in the example 2. Moreover, one side of above-mentioned Blois BL1 and BL2 is omitted, and only another side can be controlled.
[0041] Drawing 11 is the block diagram showing an example at the time of omitting above-mentioned Blois

BL2. The air which an oxygen density is condensed with the gas concentration equipment E1 using a cellulose system oxygen demarcation membrane, and is sent through a valve IA1 is mixed, and a part of air sent from the pressurization machine 7 is supplied to a stack S1. It is the same even if attached to other stacks. If each valve IA is controlled by Controller C like examples 1 and 2, since the oxygen density of each stack will change, each output current is controllable similarly.

[0042] Since the output voltage sensibility of the stack to the above-mentioned oxygen density change is high, each gas concentration equipment and Blois can be miniaturized. Moreover, the same fuel gas concentration means as a fuel-supply system is established, and you may make it control similarly. Moreover, N2, CO2, etc. can be mixed and supplied to a fuel or air from the exterior, for example, and the output current can also be controlled by the mixture control.

[0043] [Example 4] Since the output voltage of a phosphoric acid mold fuel cell changes according to cel temperature like drawing 12 , it can control the output current by controlling the temperature of the cooling water of a stack again. Drawing 13 is the block diagram of this invention example which performs the above-mentioned temperature control. Since the temperature of the cooling water of Stack Si changes with the rotational frequency of a pump 8, and/or Fan's F rotational frequencies, the output current of Stack Si is controllable by these rotational frequencies.

[0044] For example, the rotational frequency of a pump 8 and/or Fan F is controlled by the error signal acquired as compared with desired value IOi, Iim, etc. which explained the output current of Stack Si in the example 2. Moreover, the cooling water with which temperature differs at the entry of a pump 8 can be mixed, and stack temperature can also be controlled by control of the amount.

[0045] In addition, although how to control pressures, such as air and fuel gas, concentration, temperature, etc. by each example of above-mentioned this invention separately was explained, of course, you may make it control combining these controlled systems.

[0046]

[Effect of the Invention] The current of each fuel cell stack which carried out parallel connection can be controlled by this invention to suit each rated value, and load allocation can be rationalized. Moreover, when the load capacity of each fuel cell stack declines by aging, load allocation can be rationalized similarly. Moreover, reliability can be raised, while performing the above-mentioned load allocation automatically, large-capacity-izing fuel cell equipment and increasing the efficiency of maintenance.

[Translation done.]